



Rules  
2009.1

# ROBOCUP RESCUE ROBOT LEAGUE



## Technical Committee (2008-2009)

- Satoshi Tadokoro, Tohoku University, Japan (Trustee)
- Adam Jacoff, National Institute of Standards and Technology, USA (Trustee, Chair)
- Andreas Birk, International University Bremen, Germany (Exec)
- Johannes Pellenz, University of Koblenz-Landau, Germany (TC)
- Ehsan Mihankhah, K.N. Toosi University of Technology, Iran (TC)
- Jackrit Suthakorn, Mahidol University, Thailand (TC)
- Michael Hofbaur, Technische Universität Graz, Austria (2009 Local)

# RoboCupRescue ROBOT LEAGUE

Rules  
2009.1

<http://www.robocuprescue.org/> <http://robotarenas.nist.gov/competitions.htm>



## A LEAGUE OF TEAMS WITH ONE GOAL: TO DEVELOP AND DEMONSTRATE ADVANCED ROBOTIC CAPABILITIES FOR EMERGENCY RESPONDERS

USING ANNUAL COMPETITIONS TO EVALUATE, AND TEACHING CAMPS TO DISSEMINATE, BEST-IN-CLASS ROBOTIC SOLUTIONS

The RoboCupRescue Robot League competition has three main objectives: 1) to increase awareness of the challenges involved in deploying robots for emergency response applications such as urban search and rescue and bomb disposal, 2) to provide objective performance evaluations of mobile robots operating in complex yet repeatable environments, and 3) to promote collaboration between researchers.

Robot teams demonstrate their capabilities in **mobility, sensory perception, localization and mapping, mobile manipulation, practical operator interfaces, and assistive autonomous**

**behaviors to improve operator performance and/or robot survivability.**

All missions in the arenas are conducted via remote teleoperation as the robots search for simulated victims in a maze of terrains and challenges based on emerging standard test methods for response robots. Winning teams must reliably perform 7-10 missions of 20-30 minutes each from various start points to find the most victims.

As robots continue to demonstrate successes against the obstacles posed in the arenas, the level of difficulty will continually be increased so the arenas provide a stepping-stone from the



FEMA's Texas Task Force 1  
Training Facility

**COMPETITION WINNERS AND BEST-IN-CLASS CAPABILITIES take part in Response Robot Exercises organized at emergency responder training facilities with similar robot test methods and practice deployment scenarios.**



laboratory to the real world. Meanwhile, the annual competitions provide direct comparison of robotic approaches, objective performance evaluations, and a public proving ground for capable robotic systems that will ultimately be used to save lives.

INTERNATIONAL CHAMPIONSHIPS	REGIONAL OPEN COMPETITIONS
2001 Seattle, USA 2002 Fukuoka, Japan 2003 Padua, Italy 2004 Lisbon, Portugal 2005 Osaka, Japan 2006 Bremen, Germany 2007 Atlanta, USA 2008 Suzhou, China 2009 Graz, Austria	Germany Iran Japan Mexico Thailand USA

## COMPETITION VISION

When disaster happens, minimize risk to search and rescue personnel while increasing victim survival rates by fielding teams of collaborative mobile robots which enable human rescuers to quickly locate and extract victims. Specific robotic capabilities encouraged in the competition include the following:

- Negotiate compromised and collapsed structures
- Locate victims and ascertain their conditions
- Produce practical sensor maps of the environment
- Establish communications with victims
- Deliver fluids, nourishment, medicines
- Emplace sensors to identify/monitor hazards
- Mark or identify best paths to victims
- Provide structural shoring for responders

These tasks are encouraged through challenges posed in the arena, specific mission tasks, and/or the performance metric. Demonstrations of other enabling robotic capabilities are always welcome.

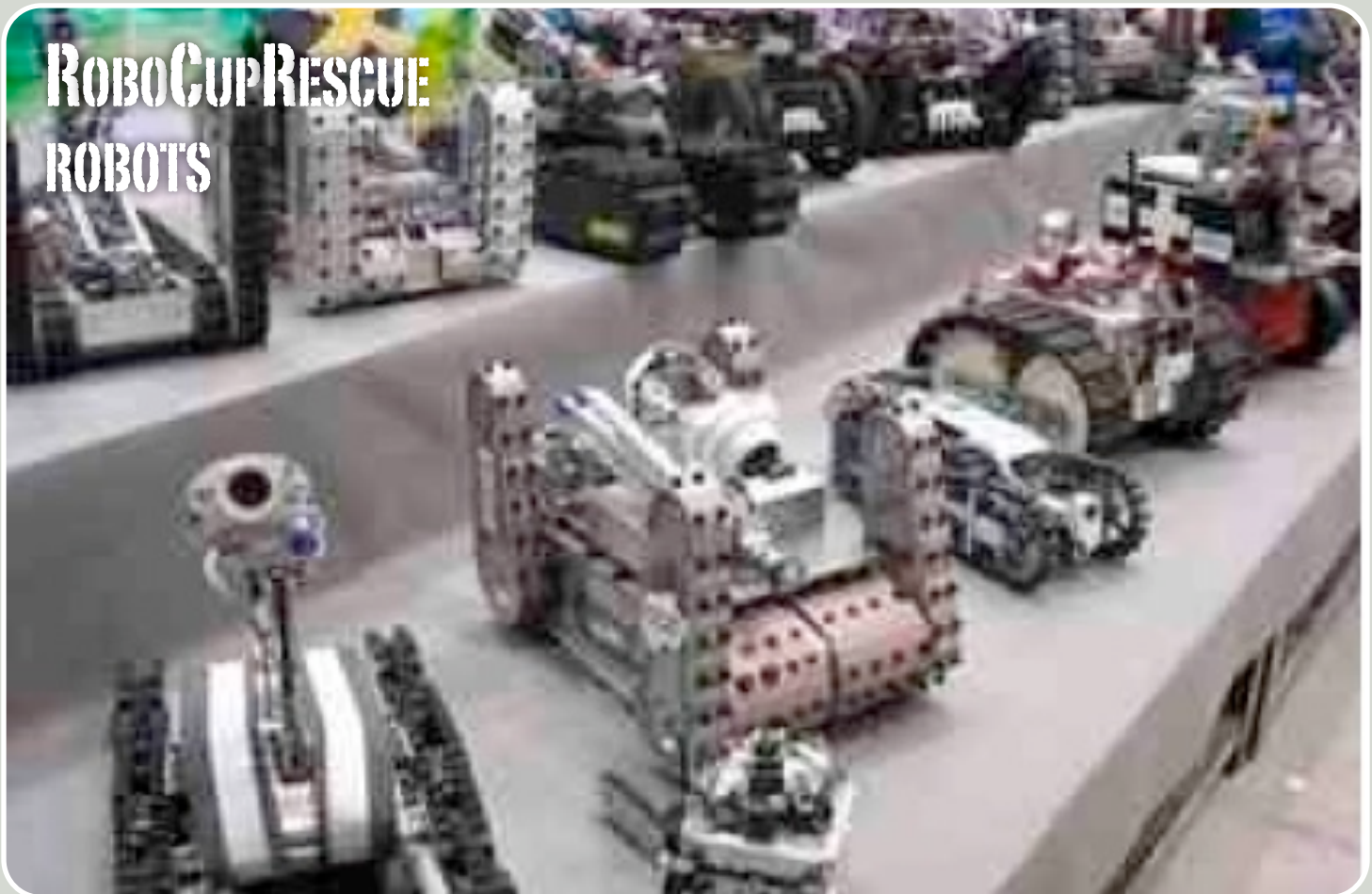
## SEARCH SCENARIO

A building has partially collapsed due to earthquake. The Incident Commander in charge of rescue operations at the disaster site, fearing secondary collapses from aftershocks, has asked for teams of robots to immediately search the interior of the building for victims.

The mission for the robots and their operators is to find victims, determine their situation, state, and location, and then report back their findings in a map of the building with associated victim data. The section near the building entrance appears relatively intact while the interior of the structure exhibits increasing degrees of collapse. Robots must negotiate and map the lightly damaged areas prior to encountering more challenging obstacles and rubble. The robots are considered expendable in case of difficulty.

**A league of teams, competing not against one another, but rather collaborating against the application domain itself to implement viable robotic capabilities.**





## Innovation is the goal, so the design space is wide open -- just make it work!

A maze of walls, doors, elevated floors and complex terrains provide various tests for robot mobility, manipulation, and mapping capabilities. Sensory obstacles, intended to confuse specific robot sensors and perception algorithms, provide additional challenges while searching for simulated victims. Intuitive operator

interfaces and robust sensory fusion algorithms are highly encouraged to reliably negotiate the arenas, locate victims, and map the results.



A common robot mobility platform for the league, the Mesa Element, is \$12K USD with serial and USARsim interfaces ([www.mesa-robotics.com](http://www.mesa-robotics.com))



Compact operator interfaces are essential.



# RoboCupRescue ARENAS

## YELLOW ARENA

FOR AUTONOMOUS NAVIGATION AND VICTIM IDENTIFICATION

- RANDOM MAZE OF HALLWAYS AND ROOMS
- CONTINUOUS PITCH & ROLL RAMPS (15°)
- DIRECTIONAL VICTIM BOXES WITH AND WITHOUT HOLES

## ORANGE ARENA

FOR ROBOTS CAPABLE OF STRUCTURED MOBILITY

- RANDOM MAZE OF CROSSING PITCH & ROLL RAMPS (15°)
- STAIRS (45°, WITH 20CM RISERS)
- RAMP (45° WITH CARPET)
- PIPE STEPS (20CM)
- CONFINED SPACES (50-80 CM UNDER ELEVATED FLOORS)
- DIRECTIONAL VICTIM BOXES WITH HOLES ONLY

## RED ARENA

FOR ROBOTS CAPABLE OF ADVANCED MOBILITY

- RANDOM MAZE OF STEPFIELD PALLETS
- DIRECTIONAL VICTIM BOXES WITH AND WITHOUT HOLES

(10M x 7.5M WITH 1.2M WIDE HALLWAYS)



YELLOW



ORANGE



ORANGE




RED

## Repeatable test method apparatuses that anybody can build and practice!

The RoboCupRescue arenas constructed to host these competitions consist of emerging standard test methods for emergency response robots developed by the U.S. National Institute of Standards and Technology through the ASTM International Committee on Homeland Security

EMERGING  
STANDARD  
ROBOT TEST  
METHODS

Operations; Operational Equipment; Robots (E54.08.01). See <http://www.astm.org/COMMIT/SUBCOMMIT/E5408.htm> for more information. The color coded arenas form a continuum of challenges with increasing levels of difficulty for robots and operators.

ARENA COLOR CODES	YELLOW	ORANGE	RED	BLUE	YELLOW, BLACK	BLACK
	Challenge robots with autonomous navigation and victim identification capabilities	Challenge robots with modest mobility capabilities in structured obstacles	Challenge robots with advanced mobility capabilities in complex terrains	Challenge robots with manipulator grasping and precision placement capabilities in complex terrain	Challenge robots with modest mobility to perform autonomous navigation tasks	Challenge robots to perform similar tasks in a realistic scenario

NEW!

NEW!

# SIMULATED VICTIMS



The objective for each robot in the competition, and the incentive to traverse every corner of the arena, is to find simulated victims. Each simulated victim is either a mannequin part of a baby doll emitting body heat and other signs of life, including motion (shifting, waving), sound (crying or audible numbers to identify), and/or carbon dioxide to simulate breathing. Particular combinations of these sensor signatures imply the victim's state: unconscious, semi-conscious, or aware.

Each victim is placed in a particular rescue situation: surface, trapped, void, or entombed based on the number of access holes and the direction they face, side or upward. Each victim also displays identification tags such as hazmat labels and eye charts that are

usually placed in hard to see areas around the victim, requiring advanced robot mobility or directed perception to identify. Once a victim is found, the robot must identify all signs of life, read the tags, determine the victim's location, and then report their findings on a human readable GeoTiff map with a pre-determined format (see mapping section).

## VICTIM DISTRIBUTION

- 4 Yellow Arena
- 4 Orange Arena
- 4 Red Arena
- 2 Yellow/Black Arena
- 2 Black Arena

## SIGNS OF LIFE TO IDENTIFY

Victims are located in directed perception boxes with limited access





holes. Every victim box contains visual acuity challenges and other signs of life:

- Form (doll or mannequin parts)
- Heat (heating pad)
- Motion (twitching or waving)
- Sound (crying or talking or standard rhyming words)
- CO<sub>2</sub> (soda or tire cartridges)
- Standard eye charts (Snellen tumbling E's) and hazardous materials labels

### VICTIM SITUATIONS

Victims can have either 1, 2, or 3 access holes (15 cm diameter) through which robots must identify the signs of life. Triple access holes will be found in arenas with more difficult tasks to perform such as full autonomy in the Yellow arena and advanced mobility in the Red arena. Orange arena victims

will mostly be viewed through single access holes. Situations are represented by viewing directions into the victim boxes. These will also vary. Victim boxes can be located below the robot on the elevated floors.

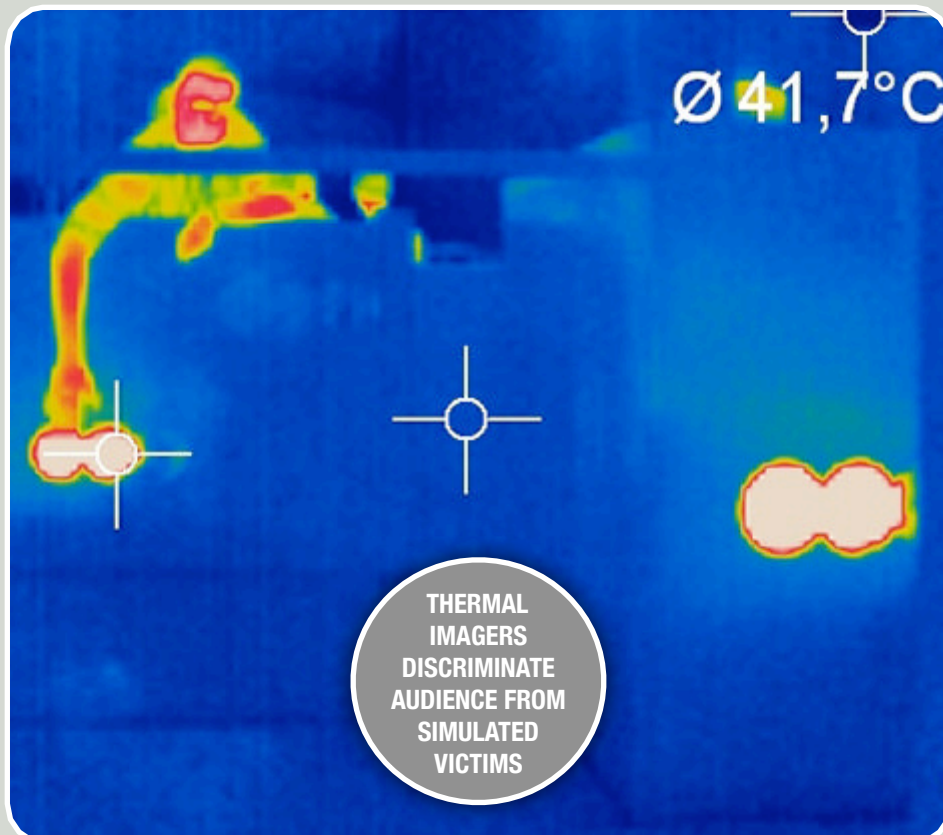
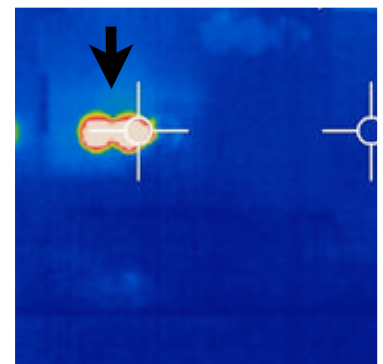
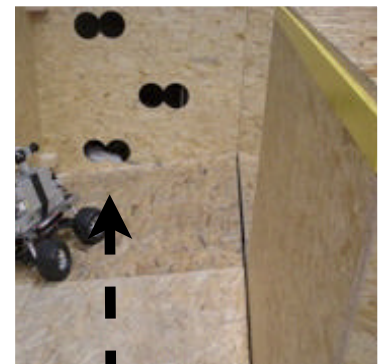
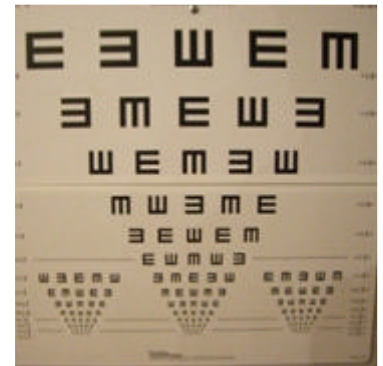
- “Trapped” victims are in boxes open on top
- “Void” victims are in boxes open to side
- “Entombed” victims are in boxes with single access holes in any direction.

### VICTIM ELEVATIONS

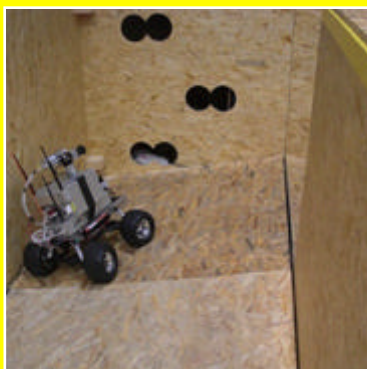
Victims can be placed at any of three levels and will be distributed equally over the course of multiple missions:

- 0-40cm
- 40-80cm
- 80-120cm.

## SIMULATED VICTIMS



# YELLOW ARENA



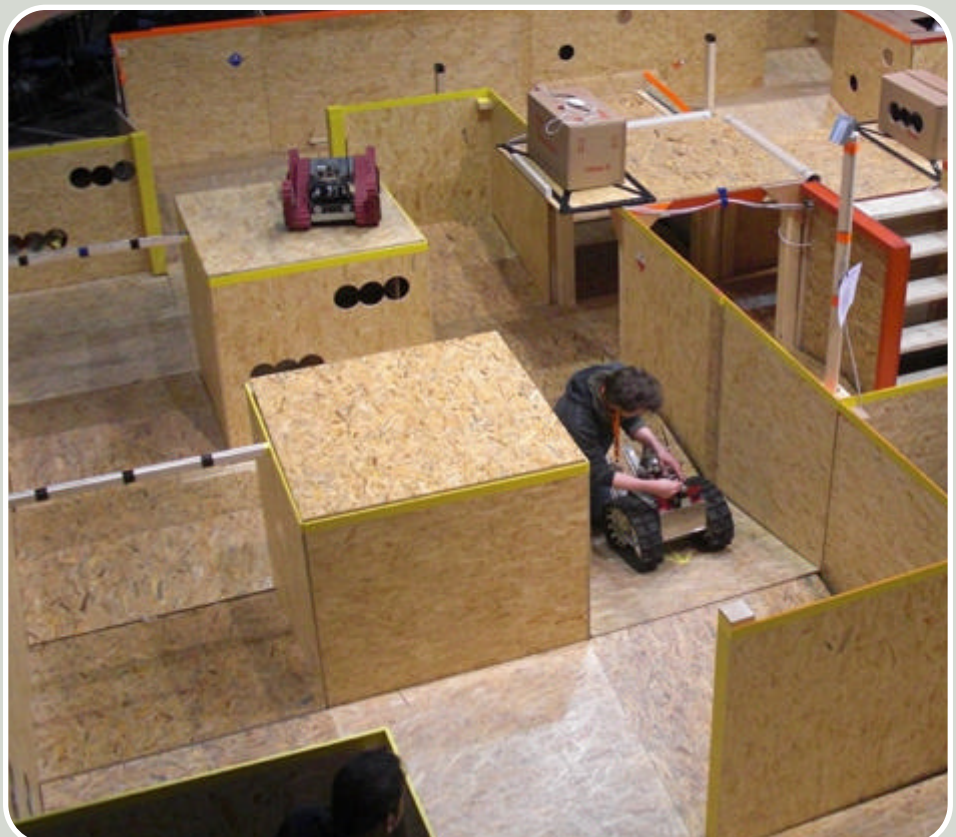
Challenges for robots with autonomous navigation and victim identification

- Random mazes with continuous 15° ramps flooring to challenge localization/mapping
- Openings to harder terrains to encourage terrain classification

The purpose of the Yellow arena is to encourage fully autonomous robot navigation and sensor fusion capabilities. It consists of random mazes of 1.2 m wide hallways and larger rooms with continuously rolling and pitching 15° ramps throughout to challenge localization and mapping implementations. Victims in the Yellow arena can only be scored by fully autonomous robots. All other robots must map the Yellow arena then navigate into the other arenas to score victim points. Random papers also cover the ramps to directly thwart odometry sensors and encourage reliable feature based approaches that can transition to realistic environments. Robots are required to autonomously search the environment until they recognize more

**AUTONOMOUS  
ROBOTS ONLY**

than one co-located sign of life associated with a victim. It should use the multiple sensor signatures to guide its approach onto the pallet directly in front of the victim, saturating all its available sensors for confidence and displaying them on the operator interface before calling the operator to verify. If the robot is more than one pallet away from the victim, or if the robot has identified a single false positive indication (e.g. a lone heating pad in the environment), the robot is penalized 1 minute. If the robot is correctly placed on the pallet in front of the victim, the judge uses all the sensor signatures displayed on the interface to score the victim. The operator is then allowed to map the victim (one keystroke) and resume the search.





# ORANGE ARENA



## Challenges for robots with modest mobility

- Crossing ramps (15°)
- Inclined plane (45°)
- Stairs (40-45°)
- Pipe-steps
- Confined spaces
- Manipulator challenges

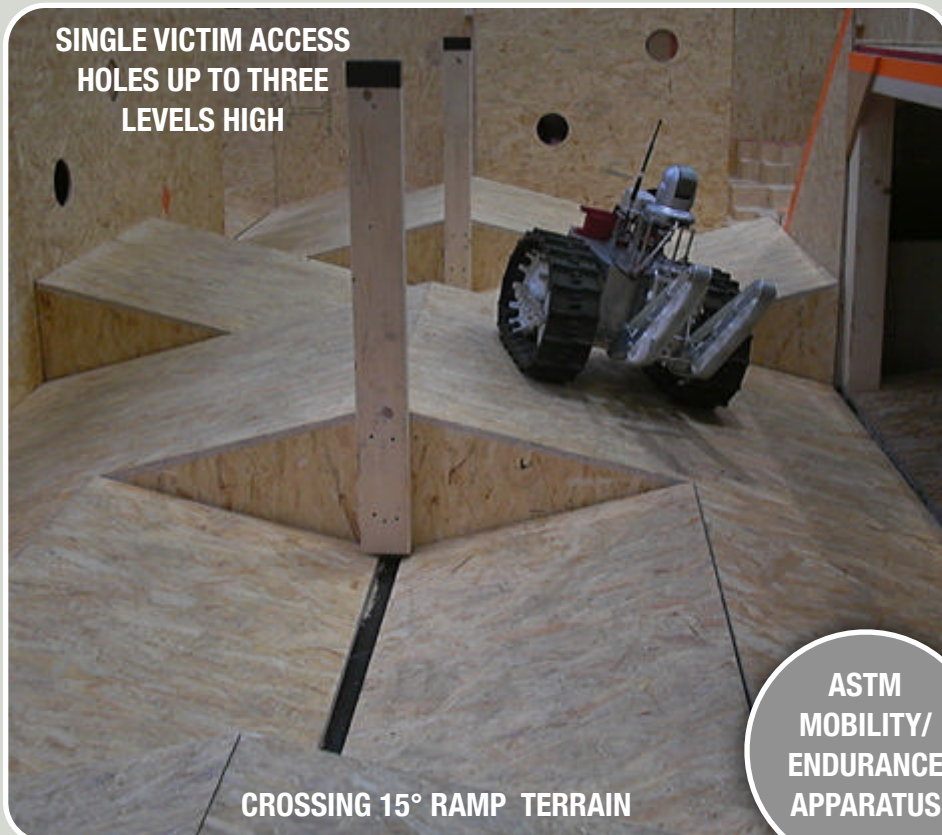
The purpose of the Orange arena is to encourage robots to negotiate more difficult structured terrains and obstacles. The random maze continues with 1.2 m wide hallways and rooms, but contain crossing 15° degree ramp flooring to increase complexity. A 45° inclined plane provides challenges for motor torque and configuration management to maximize friction. Stairs with 20 cm risers, 40° incline, and rounded wood tread edges provide access to elevated flooring platforms. So-called pipe steps which use 10 cm diameter plastic pipes stacked to form 20 cm and 30 cm high steps encourage variable geometry robots and good operator interfaces to ascend reliably. Confined spaces under the elevated

flooring platforms constrict clearance while on ramp flooring to a minimum of 50 cm vertically with complex ceiling features like stalactites made from 10 cm square posts.

Mobile manipulation challenges include negotiating the complex terrains and working on side slopes to reach victim locations that range from 0-40 cm, 40-80 cm, and 80-120 cm elevation. Mobile manipulators must also stow well to ascend the stairs/ramp and deploy while under the confined spaces to identify victims.

## MOBILE MANIPULATOR CHALLENGES

## SINGLE VICTIM ACCESS HOLES UP TO THREE LEVELS HIGH



## ASTM MOBILITY/ENDURANCE APPARATUS

## RED ARENA



**Challenges for robots with advanced mobility and exceptional remote situational awareness to negotiate very complex terrains.**

The purpose of the Red arena is to encourage innovative mobility approaches that can reliably maneuver in complex terrain. Also, to encourage independent pointing and placement of sensors while on complex terrain. The stepfield terrains provide the describable, repeatable, reproducible terrain for Red arena. Stepfields are made from 10 cm square posts cut to lengths of 10, 20, 30, 40, and 50 cm. Initially all the stepfield terrains in RoboCupRescue were arranged in random topographies which tended toward flat, hills, and diagonal hill pallets. As intended, this produced a very difficult challenge for robot developers both for mobility and for operator awareness during remote teleoperation. However, these random stepfield pallets were not producing

repeatable results over many trials, which is a necessity to become a standard test method. So the latest configurations of stepfield terrains are more symmetric rather than random. They appear as similar mobility challenges to the robot either forwards or backwards over the terrain. They

are very easy to describe and build, and so should make a good test method apparatus.

RoboCupRescue has been, and will continue to be, instrumental in capturing

performance data for robots demonstrating advanced mobility, especially in confined spaces. And these new stepfield terrains will be setup as an open room (2.4m wide x 6m long) as shown below, and as hallways with forced turns in the maze configuration.

**NEW TEST  
METHOD  
APPARATUS**





## BLUE ARENA



Challenges for mobile manipulators with coordinated controlled arms, automatic tool changing, object grasping, and/or payload carrying and precision placement capabilities.

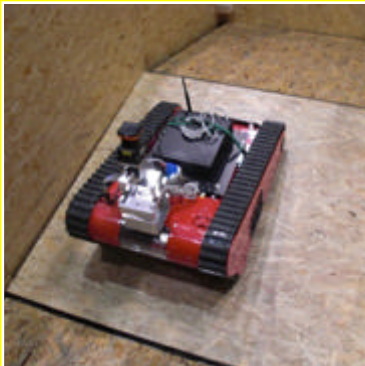
The purpose of introducing pick and place tasks in the arena is to encourage development of cartesian controlled mobile manipulators with inverse kinematics that can perform grasping and precision placement of items at different levels (0, 50, 100 cm) and reaches (30, 60 cm) while working in complex terrains (initially 15° ramps). Wood blocks (10 cm cubes covered in duct tape) provide a relatively lightweight object to manipulate. Addition of a single eye-bolt screwed into one side allows simplified grasping, hooking, or carrying and delivering on a rod. The eye-bolt is roughly 2 cm diameter. This can be considered a sensor, communications repeater, or other

**NOW  
INCLUDED IN  
THE SCORING  
METRIC**

useful object that is adapted for easy handling by a robot. There are also full water bottles (500 ml) and small radios that can be grasped and manipulated to encourage more generalized approaches needed to retrieve samples in the field. The goal is to place one of these three objects inside a found victim box to score an additional 20 points - the same incentive as the mapping capability. Two items can be carried in as a payload on the robot from the initial mission start point. But additional items must be retrieved from the Blue arena shelves. Teams may choose which items to have available and in which orientation they will be placed on the shelving targets.



# RADIO DROPOUT



Challenges for robots with modest mobility and autonomous navigation capabilities (e.g. wall following behaviors)

The purpose of introducing a radio drop-out zone (clearly marked with black/yellow hazard tape) is to encourage more autonomous behaviors on reasonably mobile robots. Bounded autonomous behaviors such as wall following for navigation should suffice for this challenge. The operator can remotely teleoperate the robot through the Orange arena to the beginning pallet of the Radio Drop-Out Zone. Once the robot is in position on the initial pallet of the zone, the operator can initiate an autonomous behavior to try to navigate the marked hallway. It will initially consist of a few turns but will get more complex toward the final missions. The floor will be

NEW FOR 2009!

continuous 15° degree ramps just like the Yellow arena. A bonus victim will be placed on the far side of the radio drop-out zone so that once the robot is through, when radio communications can resume, the victim can be found via remote teleoperation. The same victim will count again if the robot can return through the radio drop-out zone to the initial start point at the beginning of the zone. So there are 2 extra victims worth of points to find, depending on the robot's onboard sensors and mapping, of 12 total victims in all the rest of the arenas. Resets go back to the zone entrance.



ENTRANCE  
LOCATED PAST  
THE ORANGE  
ARENA



# BLACK ARENA



Mini emergency response scenario incorporated into the RoboCupRescue arenas

The purpose of introducing a mini emergency response scenario into the arenas is to begin to correlate performance seen in the arena features with tasks in more unstructured environments. For 2009, a multi-vehicle accident will be placed within the arena area and called the Black arena. These vehicles may have assorted rubble surrounding them as if they were involved in an earthquake collapse of an overpass or tunnel. Victims will likely be inside, since at the time of the accident the vehicle was being driven on a roadway.

One side of the accident will have more complex terrain associated with a possible collapse. This will be

accessible from the Red arena stepfield terrain.

The other side of the vehicles may be more relatively clear as if it were a hazardous materials event rather than a collapse. This side will be accessible from the Yellow and Orange arenas.

NEW FOR 2009!

Directed perception tasks to look into the windows to identify victims, and into the trunk and other areas for potential hazards will be required. Finding victims and hazards (identified clearly by hazmat labels for now), will score points just like in the rest of the arenas.

This Black arena will also be used by visiting emergency responders operating robots.



# AERIAL ARENA

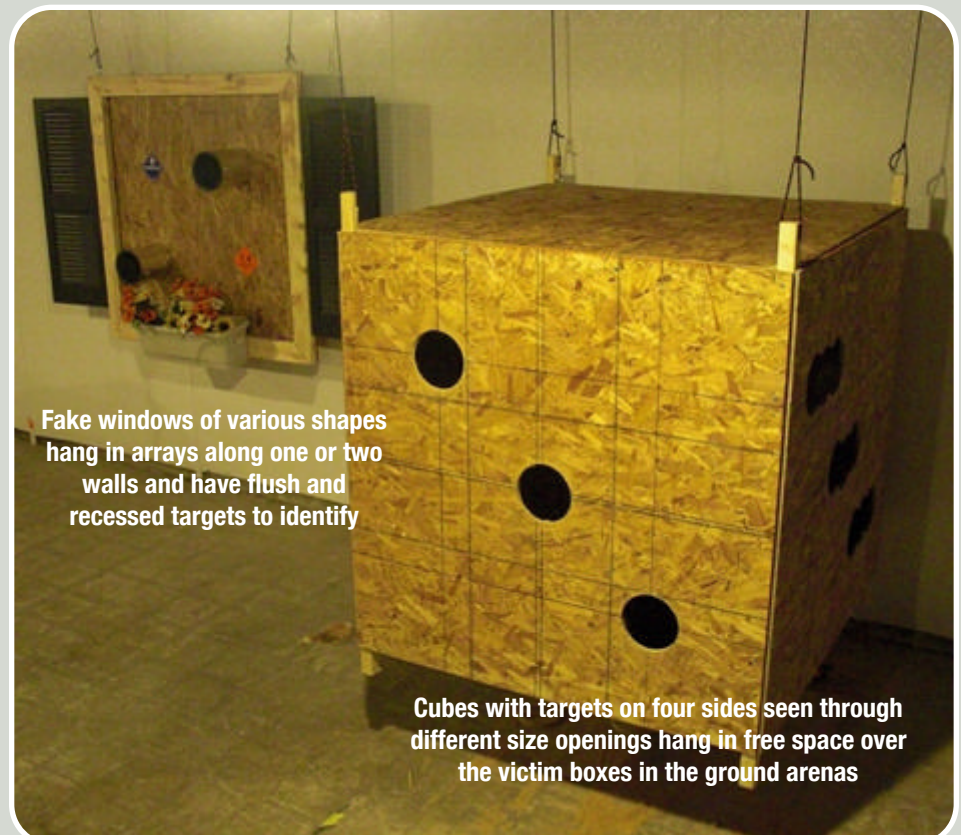


Challenges for micro/mini aerial vehicles with autonomous stand-off and station-keeping capabilities

The purpose of the Aerial arena is to encourage more autonomous behaviors on micro/mini aerial vehicles. Specifically, this event is focused on vertical take-off and landing aerals, or so-called quad-rotor aerals, that are under 2 kg total weight. The tasks to be demonstrated will encourage vertical and horizontal station-keeping with automatic standoff and centering on windows. There will also be victim boxes with targets hanging in free-space over the ground arenas. Though the aerial victim boxes may be hanging nearby each other to add complexity. This will extend the same basic tasks from the ground arenas into the aerial domain. So all the aerial targets will contain similar signs of life

such as form, heat, and sound to challenge the aerial's ability to deploy sensors both for station-keeping and for target identification. There are specific test methods for law enforcement tasks involving these type of aerial vehicles. They include mannequin heads in front or side view to identify against pictures. This may be included in some of the targets.

NEW FOR 2009!



Fake windows of various shapes hang in arrays along one or two walls and have flush and recessed targets to identify

Cubes with targets on four sides seen through different size openings hang in free space over the victim boxes in the ground arenas

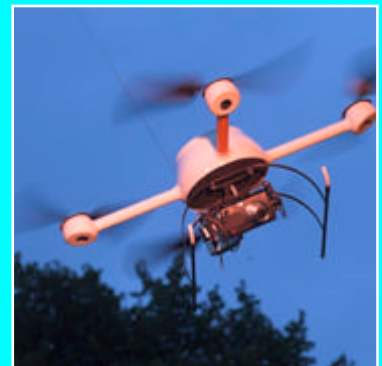




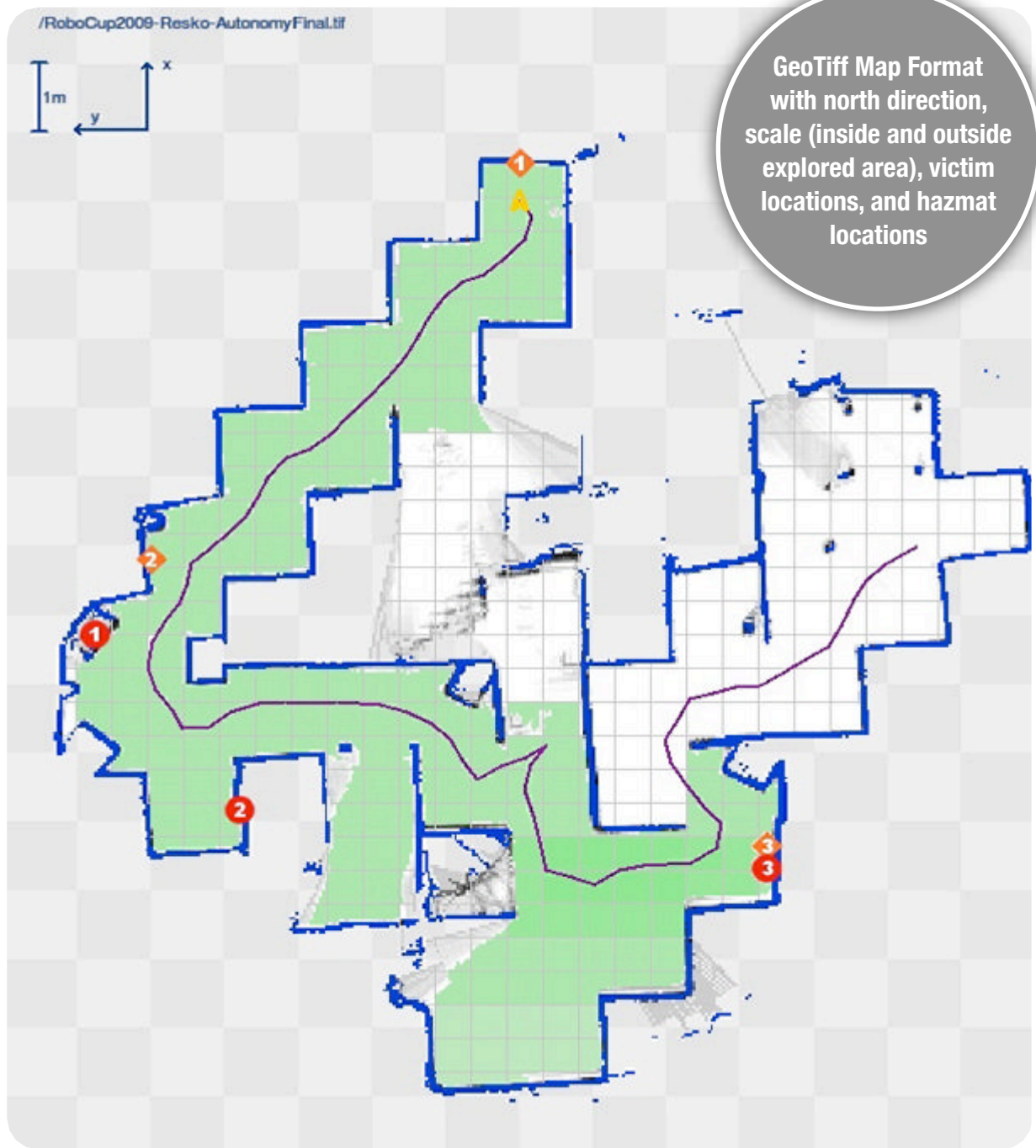
Quad Rotor  
Micro/Mini Aerial  
Vehicles  
( $<2\text{kg}$ )



## AERIAL ARENA



Challenges for micro/mini  
aerial vehicles with  
autonomous stand-off and  
station-keeping capabilities



## GEO TIFF MAPPING

Introduction of a mandatory GeoTiff map format solves two problems: 1) it provides for a standard map format that can be used to compare maps both to ground truth arena designs and to other maps across missions and teams. 2) it also allows us to develop algorithmic scoring metrics to automatically evaluate the location accuracy of victims initially, and ultimately map quality more generally. As a starting point, here is a source to investigate from the RoboCupRescue Virtual robot competition: [http://www.robocuprescue.org/wiki/index.php?title=VRCompetitions#Map\\_Format\\_and\\_A\\_priori\\_Information](http://www.robocuprescue.org/wiki/index.php?title=VRCompetitions#Map_Format_and_A_priori_Information)

The map color scheme should highlight the important features without distraction. The goal is to have certain key information be immediately identifiable to make the map useful as a printed page while beginning to explore all the potential of



a graphical viewer that allows interacting with the map (potential printing in black and white is also a secondary consideration). So below is a proposed description of a 2009 GeoTIFF map format for the RoboCupRescue Robot League competitions. The colors for each element are unique so that algorithmic scoring methods can be used without confusion. The values for gray have not exactly the same value for R, G and B to indicate that this particular pixel was modified. This makes it easy to reconstruct the original value when needed.

**FILENAME:**

DARK BLUE (RGB: 0, 44, 207) TEXT  
For example, "RoboCup2009-TeamName-Mission1.tiff" displayed in the upper left corner to identify the map, make it sort properly in a directory, and findable on a computer.

**MAP SCALE:**

DARK BLUE (RGB: 0, 50, 140) TEXT AND EXACTLY 1 METER LONG LINE  
Display this in the upper right corner to indicate the scale of the map.

**MAP ORIENTATION:**

DARK BLUE (RGB: 0, 50, 140) TEXT ("X" AND "Y") AND ABOUT 50 cm LONG ARROWS  
Display this next to the map scale. It gives the orientation for the victim location in the victim file. Must be a right-handed coordinate system: X points upwards, Y to the left.

**UNEXPLORED AREA GRID:**

LIGHT/DARK GREY (RGB: 226, 226, 227/RGB: 237, 237, 238) CHECKERBOARD WITH 100CM SQUARES  
This solid checkerboard pattern should show the unexplored area and provide scale on all sides of the mapped area. It should also print in black and white without ambiguity with other areas potentially turned grey in the process.

**EXPLORED AREA GRID:**

BLACK (RGB: 190,190,191) GRID WITH 50CM GRID AND ABOUT 1 CM THICK LINES (use a one pixel line in the map)  
This grid should only appear in the explored area, behind any walls, victim locations, or other information. The grid should be aligned with the checkerboard pattern of the unexplored area, but twice as fine to allow visual inspection of wall alignments.

**INITIAL ROBOT POSITION:**

YELLOW (RGB: 255, 200, 0) ARROW

This should mark the initial position of the robot and always be pointed toward the top of the map.

**WALLS AND OBSTACLES:**

DARK BLUE (RGB: 0, 40, 120) FEATURES

This should indicate the walls and other obstacles in the environment. The color should make the walls stand out from everything else.

**SEARCHED AREA:**

WHITE CONFIDENCE GRADIENT (RGB: 128, 128, 128 to RGB: 255, 255, 255)

This should be based on the confidence that the area is really free. It should produce a clean white when seen as free by all measurements and nearly untouched when undecided, that is, nearly equally seen as occupied as free, to produce a dither effect.

**CLEARED AREA:**

LIGHT GREEN CONFIDENCE GRADIENT (RGB: 180, 230, 180 to RGB: 130, 230, 130)

This should be based on a history of 1-50 scans to show the area cleared of victims with confidence. This should also factor in the actual field of view and range of onboard victim sensors – noting that victim sensors don't typically see through walls!

**VICTIM LOCATION:**

SOLID RED (RGB: 240, 10, 10) CIRCLE WITH ABOUT 35CM DIAM CONTAINING WHITE (RGB) TEXT "#"

This should show the locations of victims with a victim identification number such as "1" in the order they were found. Additional information about this victim should be in the victim file noted below.

**HAZARD LOCATION:**

SOLID ORANGE (RGB: 255, 100, 30) DIAMOND WITH ABOUT 30CM SIDES CONTAINING WHITE (RGB) TEXT "#"

This should show the locations of hazards with an identification number such as "1" in the order they were found. Additional information about this hazard should be in the hazard file noted below.

**ROBOT PATH:**

MAGENTA (RGB: 120, 0, 140) LINE ABOUT 2CM THICK

This should show the robot path.



# ROBOCUP RESCUE SCORING

The purpose of the scoring metric is to encourage development of complete and reliable robotic systems while emphasizing certain best-in-class capabilities and integration of critical sub-components. The scoring approach centers around finding simulated victims distributed roughly uniformly throughout the arenas. Some victims must be found autonomously, in the Yellow arena for example, but there are essentially the same amount of points available on every victim. So robots with more capabilities, such as autonomous navigation and victim identification, have more victims available to find. Similarly, robots with advanced mobility capable of negotiating the Red arena stepfields have access to more victims. Robots with manipulators that can reach and search victim boxes on the highest elevation (80-120 cm), have access to modestly more victims if they can also deploy their manipulator under the elevated flooring platforms to find the confined space victims.

In this way, the league doesn't assign specific points associated with different capabilities, for example autonomy vs. remote teleoperation. The total victims available for different robotic implementations are well known, as are the situations in which they will be located. Victims will be moved around the arena each round to ensure that the winning robots have reliably negotiated the entirety of the arenas across multiple missions. Victim locations may also get harder, search times may get shorter, or arena sizes may get larger as the competition progresses toward the Finals to ensure that the best robots are appropriately challenged. But in the end, **this is a league of teams not competing against one another, but**

**rather collaborating against the application domain.** And as such, we are focused toward teams demonstrating world-class capabilities in the arenas so that the rest of the league may appreciate, learn, and ultimately leverage new and exciting approaches.

## VICTIMS PER ARENA

- 4 Yellow
- 4 Orange
- 4 Red
- 2 Black/Yellow (radio drop-out)
- 2 Black (mini scenario)

## THE SCORING METRIC

Robots must be on the pallet directly in front of the victim to score points. Several key capabilities are specifically rewarded in the scoring metric. Since victims are distributed across all arenas, more capable robots have access to more victims. In general, up to 70 points are available per victim found:

### VISUAL IDENTIFICATIONS (10 pts)

- (5 pts) Hazmat labels in victim boxes
- (5 pts) Eye charts in victim boxes

### OTHER IDENTIFICATIONS (20 pts)

- (5 pts) Visual motion algorithms
- (5 pts) Thermal signatures
- (5 pts) 2-way audio
- (5 pts) CO2 detection

### PAYLOAD DELIVERY (20 pts)

- (20 pts) Placing of payloads into found victim boxes.

### ARENA MAPPING (20 pts)

- (10 pts) Quality of geotiff map
- (10 pts) Accuracy of victim locations

### PENALTIES (-10 pts per event)

- Assessed when arena elements need to be replaced





# ROBOT LEAGUE MISSION FORM (v2009.1)

TEAM	RD/MSN	START/END
------	--------	-----------

BOT #	ROBOT NAME	TELE	AUTO	CAMERA	HEAT	MOTION	SOUND	CO <sub>2</sub>
		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

BOT #	ROBOT NAME	TELE	AUTO	CAMERA	HEAT	MOTION	SOUND	CO <sub>2</sub>
		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

BOT #	ROBOT NAME	TELE	AUTO	CAMERA	HEAT	MOTION	SOUND	CO <sub>2</sub>
		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

START POINT
-------------

PENALTIES				
<input type="radio"/> 10	<input type="radio"/> 10	<input type="radio"/> 10	<input type="radio"/> 10	<input type="radio"/> 10

RADIO DROP ZONE	
<input type="radio"/>	

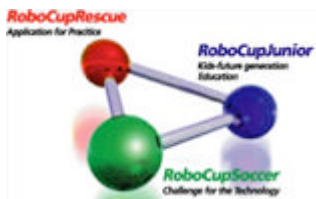
RESET	BOT#	ARENA	ID	HOLE	TAGS	SIGNS OF LIFE	PLACE	MAP	SCORE	NOTES
					5	5	5	5	5	20
	V1									
	V2									
	V3									
	V4									
	V5									
	V6									
	V7									
	V8									
	V9									
	V10									
	V11									
	V12									
	V13									

NOTE: COUNT VICTIM SCORE FOUND IN RADIO DROP-OUT ZONE  
TWICE IF SUCCESSFUL AUTONOMOUS RETURN

JUDGE NAME	REFEREE NAME
------------	--------------

PENALTIES	POINTS	=	TOTAL
<input type="text"/>	<input type="text"/>		<input type="text"/>

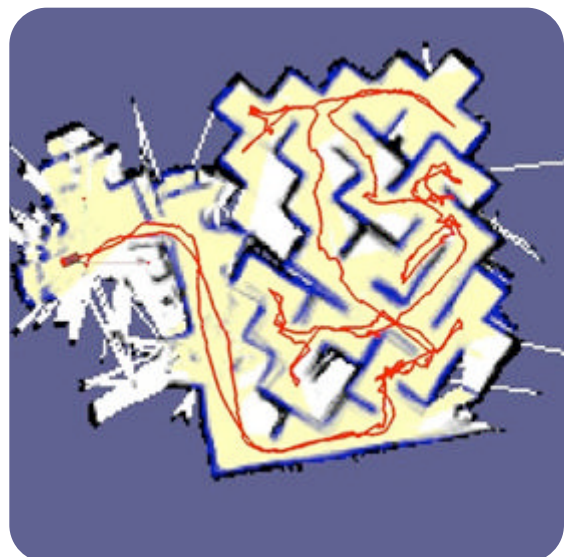
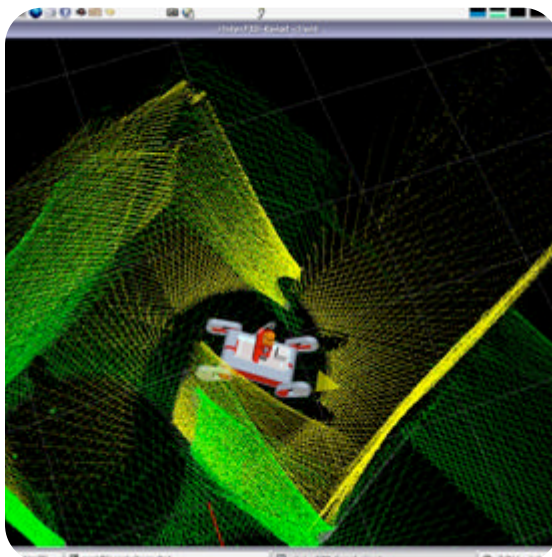




# ROBOCUP RESCUE AWARDS



RoboCupRescue  
Winners and Best-In-  
Class Awardees get to  
participate in Response  
Robot Evaluation  
Exercises in Responder  
training facilities





# AWARDS

## CHAMPIONSHIP AWARDS

1st, 2nd, 3rd place awards will be given to teams with the highest cumulative scores from 7-10 missions.

## BEST-IN-CLASS AWARDS

Best-In-Class awards will be given to individual robots that do the following:

### **Best-In-Class Autonomy:**

- 50%: Find the most Yellow arena victims during regular missions.
- 50%: Produce the best map during a Best-In-Class mission to map the entire Yellow and Orange arena with no attention to victims.

### **Best-In-Class Mobility:**

- 50%: Find the most Red arena victims during regular missions.
- 50%: Travers the most Red arena obstacles in a Best-In-Class mission with no attention to victims. Score 1 point per obstacle, per direction of traverse (i.e. forward/up and backward/down scores two points) on each of the following: stairs, ramp, pipe-step, red stepfield hill pallets.

### **Best-In-Class Mobile Manipulation:**

- 50%: Place the most items into victim boxes during regular missions.
- 50%: Pick the most items from the Blue arena shelves during the Best-In-Class mission to quantify operational manipulator reach in two shelf conditions: open and covered by a shelf above.



**Championship awardees get trophies. Best-In-Class awardees get trophies or certificates and an opportunity to teach their implementation at the next camp.**



# ROBOCUPRESCUE CONTRACTS

## TECHNICAL COMMITTEE

**SATOSHI TADOKORO (TRUSTEE)**

[<TADOKORO@RM.IS.TOHOKU.AC.JP>](mailto:TADOKORO@RM.IS.TOHOKU.AC.JP)

**ADAM JACOFF (EXEC, CHAIR)**

[<ADAM.JACOFF@NIST.GOV>](mailto:ADAM.JACOFF@NIST.GOV)

**ANDREAS BIRK (EXEC)**

[<A.BIRK@JACOBS-UNIVERSITY.DE>](mailto:A.BIRK@JACOBS-UNIVERSITY.DE)

**JOHANNES PELLENZ (TC)**

[<PELLENZ@UNI-KOBLENZ.DE>](mailto:PELLENZ@UNI-KOBLENZ.DE)

**EHSAN MIHANKHAH (TC)**

[<EHSANMIHANKHAH@YAHOO.COM>](mailto:EHSANMIHANKHAH@YAHOO.COM)

**JACKRIT SUTHAKORN (TC)**

[<EGJST@MAHIDOL.AC.TH>](mailto:EGJST@MAHIDOL.AC.TH)

**MICHAEL HOFBAUR (2009 LOCAL CHAIR)**

[<MICHAEL.HOFBAUR@TUGRAZ.AT>](mailto:MICHAEL.HOFBAUR@TUGRAZ.AT)

## ARENA DESIGN ISSUES

[RobotTestMethods@nist.gov](mailto:RobotTestMethods@nist.gov)

## EMAIL LIST SERVER AND ARCHIVE

(Hosted by Georgia Tech University)

The purpose of this email list is to help teams quicken the pace of advancement for response robots by:

- providing practical help in overcoming technical problems that arise,
- promoting and leveraging successful approaches and implementations,
- encouraging collaboration with other teams demonstrating complimentary technical capabilities in mobility, sensory perception, planning, mapping, and practical operator interfaces.

The ultimate goal, of course, is to develop complete and effective robotic systems that can be deployed in the field to save lives. Hopefully, this email list will help get us there faster, and make it easier for teams to contribute along the way.

**To subscribe, go to:**

<https://mailman.cc.gatech.edu/mailman/listinfo/robocup-rescue-r>



# AWARDS

## BEST-IN-CLASS AWARDS

Best-In-Class awards will be given to individual robots that do the following:

### **Best-In-Class Autonomy:**

- 50%: Find the most Yellow arena victims during regular missions.
- 50%: Produce the best map during a Best-In-Class mission to map the entire Yellow and Orange arena with no attention to victims.

### **Best-In-Class Mobility:**

- 50%: Find the most Red arena victims during regular missions.
- 50%: Travers the most Red arena obstacles in a Best-In-Class mission with no attention to victims. Score 1 point per obstacle, per direction of traverse (i.e. forward/up and backward/down scores two points) on each of the following: stairs, ramp, pipe-step, red stepfield hill pallets.

### **Best-In-Class Mobile Manipulation:**

- 50%: Place the most items into victim boxes during regular missions.
- 50%: Pick the most items from the Blue arena shelves during the Best-In-Class mission to quantify operational manipulator reach in two shelf conditions: open and covered by a shelf above.

# ROBOCUPRESCUE ROBOT LEAGUE

## RULES-AT-A-GLANCE (2009.1)

### NEW THIS YEAR

- A radio drop-out zone (Yellow/Black arena) will be introduced past the Orange arena to encourage mobile robots to demonstrate autonomous navigation capabilities such as wall following or other behaviors.
- A payload delivery challenge will be introduced to encourage mobile manipulators to use inverse kinematics to perform automatic payload grasping and tool changing, object retrieval, and precision placement tasks on complex terrains.
- Standard two-way communications test methods will be used to verify victim identification by a remote operator (and judge) using randomly spoken numbers played as audio files on speakers within victim boxes. Initially a computer voice will read a spreadsheet in English, but eventually other languages will also be used.

### MISSION OVERVIEW

- Teams should queue at the paddock entry with their robot(s) and operator interface(s) prior to their scheduled start time.
- 15-30 minute missions include robot placement at the start point and operator station setup. Each team is responsible for making sure victims in the arenas are functional (heat, batteries, tags) prior to mission start.
- The operator station will be limited to a 120 cm wide x 60 cm deep desk with walls. Teams are allowed only one operator in the operator station at any time during missions. Teams may switch operators whenever necessary.
- All robot start points will be in or around the Yellow arena and facing the same direction (marked as "north" on your map). The initial direction may be facing a wall. Teams with multiple robots will be co-located at the start

point (as near as possible) and facing the same direction.

- Victim placements will be known to the operators and audience prior to missions, and changed each round to ensure complete arena coverage over multiple missions.

- All teams should map the Yellow arena, but robots must perform autonomous navigation and victim identification to score Yellow arena victims. Operators may remotely teleoperate the robot at any time to navigate into the Orange and Red arenas but must return to the start point to resume autonomous searches to find Yellow arena victims.

- Teleoperative robots can only score Orange or Red arena victims, which are likely placed on both sides of the Yellow arena to encourage complete mapping of all arenas.

- An operator (or team leader) may request a "ROBOT RESET" to fix a robot during a mission, but suffers loss of accumulated victim points, maps, and elapsed time. The robot must re-start the mission from the initial mission start point and work for the remaining time available. The robot can be teleoperated to the start point to fix with no loss of points.

- GeoTiff maps are required and will be compared to ground truth for accuracy. Map quality will be based on Technical Committee review.

- Bumping penalties will be assessed if the administrator must replace or fix arena elements prior to next mission.

- The league will assign 802.11A channels for practice and missions. All league SSID's must be "RRL-TEAMNAME". No other radios using either 2.4 GHz or 5 GHz radio frequencies are allowed.



### VICTIMS PER ARENA

- 4 Yellow
- 4 Orange
- 4 Red
- 2 Black/Yellow (radio drop-out)
- 2 Black (mini scenario)

### THE SCORING METRIC

Robots must be on the pallet directly in front of the victim to score points. Several key capabilities are specifically rewarded in the scoring metric. Since victims are distributed across all arenas, more capable robots have access to more victims. In general, up to 70 points are available per victim found:

#### VISUAL IDENTIFICATIONS (10 pts)

- (5 pts) Hazmat labels located in victim boxes
- (5 pts) Eye charts located in victim boxes

#### OTHER IDENTIFICATIONS (20 pts)

- (5 pts) Visual motion algorithms
- (5 pts) Thermal signatures
- (5 pts) 2-way audio
- (5 pts) CO2 detection

#### PAYLOAD DELIVERY (20 pts)

- (20 pts) Placing of payloads into found victim boxes.

#### ARENA MAPPING (20 pts)

- (10 pts) Quality of geotiff map
- (10 pts) Accuracy of victim locations

#### PENALTIES (-10 pts per event)

- Assessed when arena elements need to be replaced